The user interfaces of intelligent assistance systems

Functions, Problems and Design Characteristics

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Over the last decades the field of human computer interaction has developed various personified types of software and computer based artifacts like virtual agents or embodied conversational agents and hardware-based forms of anthropomorphic interpretation like robots. Furthermore, the increased quality and reliability of systems for tracking human behavior facilitate the interpretation of natural human body actions. Hitherto studies concerning the user interfaces of autonomous intelligent systems are focused mainly on research and development of particular interface variations for specific applications. In this paper the coherence between a user interface and the representation of intelligence and autonomy as well as questions concerning the perception and acceptance of those systems by the user will be discussed from a general perspective.

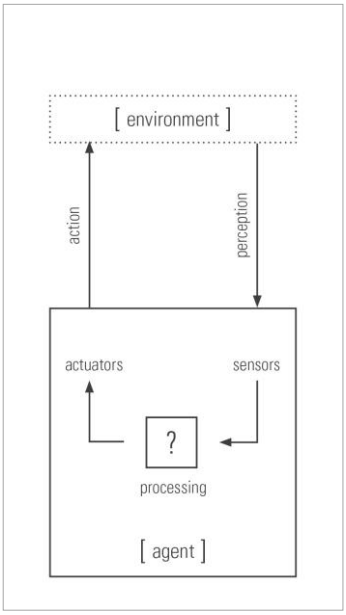
Key words: Virtual Agent, User Interface, Intelligent Autonomous System

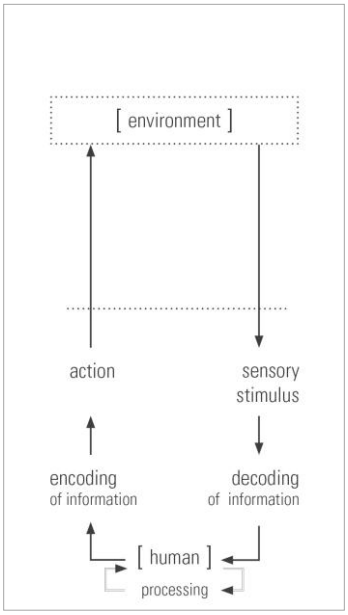
1. Introduction

Intelligent assistance systems are based on a specific kind of software, the software agent. However, the term ‘agent’ has different meanings in the context of computerized applications. To analyze the user interface (UI) of those systems it is necessary to understand these different meanings as well as characteristics and behaviors of the technical systems itself. In 1997 SÁNCHEZ provided an overview of the functions and meanings of software agents in „A Taxonomy of Agents“ and differentiated them as „Programmer Agents“, „Network Agents“ and „User Agents“ [33]. Programmer and network agents are typical software agents developed to study artificial intelligence (AI). In this context the term ‘agent’ is used as metaphor to describe the structure and behavior of these special systems [33]. From this perspective of AI an agent is defined as being able to perceive its surroundings with sensors and act in these surroundings by actuators [31]. In accordance with BURKART (2003) a more general definition of an agent is somebody or something that acts independently or by the order of someone else. In comparison to conventional software a software agent shows a higher level of target-orientation, autonomy, interactivity (reactive and proactive), logical reasoning, compliance and social behavior [6]. The scientific base of UIs analyzed in this article, are computerized intelligent systems, which are able to interact and communicate with humans. These systems come with a specifically application knowledge, are adaptive to environmental influences and able to take decisions independently [39]. The use of technical sensors for measuring user data and environment conditions allows their operation in complex systems [26].

Besides this, the term agent is used in the context of mostly visual, computerized characters. SÁNCHEZ summarizes such types as „User Agent“ [33]. Thereby the term agent is used in a more original kind. The idea for virtual agent results from the need to support humans to interact in the virtual environment of data and information. This kind of virtual agent is equally unshaped as programmer and network agents, but it is necessary to develop a representation in order to allow the interaction between the human user and the agent. This emphasizes the role of the representation of the virtual agent for the interaction between the computer-based system and the user. “Embodied Conversational Agent” (ECA) [7] are one possible type of this representation. Alternative names are virtual agent, chatbot, virtual companion, virtual assistant, virtual personal assistant, as well as intelligent or smart assistant. SÁNCHEZ merged them in a sub-group of “User Agents” called “Synthetic Agents“. To follow the general idea, that the user agent is in principle an intelligent and interactive software system, which interacts directly with the user, there are different possibilities for the representation of such systems. Those special types of UIs are in the center of the following analysis.

The UI is the representation of the system for the user and allows the user to interact with the system. In this tenor the UI is the whole appearance of the system, including all real physical components and the represented content [13]. By designing the UI of autonomous, intelligent and interactive systems, the interface designers formulate the interaction and communication between the system and the potential users together with computer scientists and engineers. Designers from different fields are needed to analyze and integrate the performance of these technical artifacts with diverse environments and systems [23, 32].





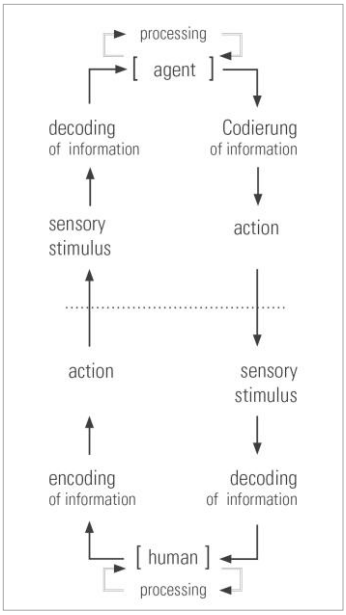


Figure 1(left): The structure of agents - referring to [31] Figure 2.1 S. 56

Figure 2 (center): simple perception-action-cycle to illustrate the human behavior.

Figure 3 (right): double perception-action-cycle to illustrate the communication and interaction cycle between agent systems and human users

Designers have to consider that functional and formal aspects [21] influence the human perception of the system, the ability of the system to percept human behavior and the interaction between system and user. Both, the

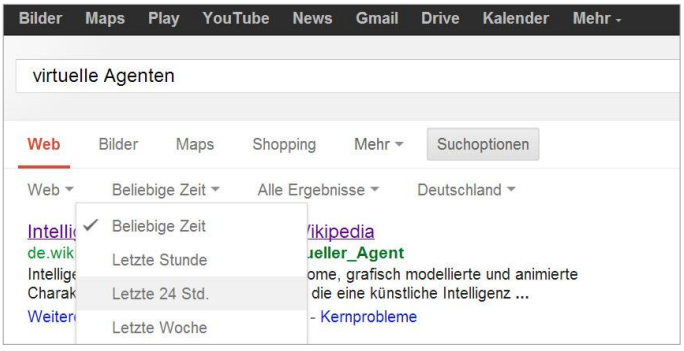
functional as well as the formal composition of the system, depends on the scenario the system is developed for. The functional composition is based on information about specific environment conditions, skills and properties of the potential users or available technical conditions. The formal composition is based on the perception and experiences of the user. Design aspects like geometry, dimension and format, materials and colors of sensors, actuators and the thereby represented information, structure, orientation and behavior of the so composed system affect the user behavior. The influence of design criteria and the coherence between formal aspects and product association was analyzed among others in the context of KANSEI engineering [5].

2. Overview to the existing design models for the UI of agent-based software

The following overview reviews literature on different kinds of intelligent assistance systems like ECAs and robots as well as examples and prototypes available on the web or on the market. According to common interface categories [34] and the fields of research wherein the examples are developed, the following five groups have been identified.

2.1 Agent-based software with conventional WIMP based GUI

Although new options of hardware interfaces under the heading of "tangible interaction" [16], "wearable computing" [22], "context aware computing" [24], "ubiquitous computing" [37] or "pervasive computing" [2] are regularly introduced to the market, the graphical user interface (GUI) is currently the most often used type of interface. Therefore it is a frequently used interface for common agent-based applications like search engines and data file systems. Electronic marketplaces, simulation systems for transport and logistics as well as web search engines, used in private context, are common examples [26, 28, 31]. The GUI is based on the metaphor to interact in and with windows, icons and menus through point-and-click devices (WIMP). The interface consists of hardware (a combination of display, mouse and keyboard or even multi-touch-displays) and the represented information, which might be text, symbols, images or even videos. The interactivity is limited to the information processing by the software itself. Therefore, the communication between the user and the system cannot be described as interactive in the sense of natural or "reality-based Interaction" [17].



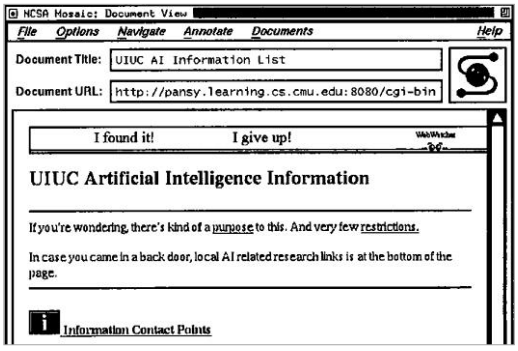


Figure 4 (left): screenshot of the web-based search engine [40]

Figure 5 (right): Web Watcher, a "web-based information search agent" [1]

2.2 Chatbots

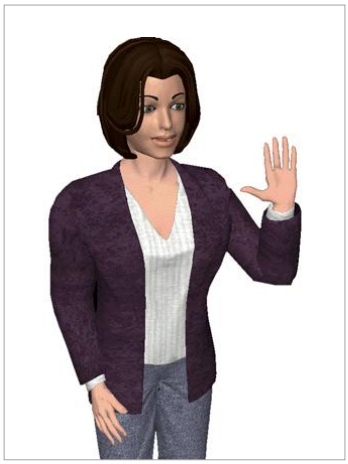
Chatbots are text-based dialog systems, which are particularly used as information systems in the field of online customer support. Numerous examples are available in online market sources like http://www.chatbots.org/ or on platforms like Chatterbox Challenge Contest (http://www.chatterboxchallenge.com/). Usually the interface of these systems is reduced to a window wherein the user communicates with the system in a text-based manner. Often this window is viewed on a separate level of the display and complemented by the visualization of human or animated figures. The user can interact with the system through keyboard and mouse. The appearance of such systems is related to the familiar format of online and telephone chat.

Figure 6 (left): virtual customer support system “Sabine” [41]

Figure 7 (right): virtual customer support system “Chat-O-Mat®” [42]

2.3 Animated Characters and Embodied Conversational Agents

ECAs are special “[…] computer interfaces represented by way of human or animal bodies”, they are “lifelike” and “[…] believable in their actions and reactions to human users.” They are furthermore “[…] specifically conversational in their behaviors and specifically humanlike in the way they use their bodies in conversation” [7].



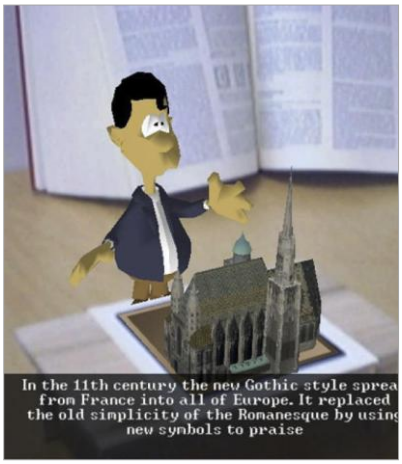


Figure 8 (left): ECA Rea [7]; Figure 9 (center): ECA Greta [43]; Figure 10 (right): Mr. Virtuoso [36]

The research in the field of ECAs is concentrated on the analysis [18, 27, 29, 30] and reproduction of human behavior and conversational functions like turn taking, feedback und repair mechanisms. In the majority of cases

ECAs are still prototypes developed within research projects. Less complex characters like the Microsoft Agents (Clippy, Merlin, Peedy, Genie and Robby) are available in context of software assistance systems. The scope of application may be in the area of e-learning, e-commerce or entertainment [7]. In regard to the interactivity with the user, ECAs differ fundamentally from the UIs named above. First, they use a different set of technical sensors to detect the behavior of the user. Second, complex multidimensional feedback can be generated by visual and auditory presentation. The main purpose of the UI is the visualization of a three-dimensional virtual character on conventional displays or larger projection systems. Mostly these are anthropomorphic characters and less frequently animalistic forms. In addition, current research projects examine the influence of virtual and augmented reality [15].

2.4 Agent-based software with voice user interface

In the case of voice user interfaces (VUI) the user interacts with the system via spoken word. The information output consists of a combination of prerecorded sound or synthesized speech and is provided over a speaker system. Currently used and well-known examples of intelligent systems with VUIs are Apple “Siri” and Google “Voice Search”. Intelligent navigation systems and complex information systems as used for telephone customer support are other examples [8, 34].

2.5 Autonomous robots

In regards to the definition and function of software agents, autonomous robots are the most representational kind of UI for intelligent assistance systems. Comparable to the examples of ECAs most models of autonomous robots described in literature are prototypes or purpose-built devices. For example autonomous underwater vehicles (AUVs) [38] are used as research robots to explore areas inaccessible to humans. Military devices are often leg- and wheel-based or also flying robots that are developed for exploration and transport purposes. Application and service robots are important in medicine biology, but are also useful for entertainment and house keeping. [3, 4]

These systems are complex unities of hardware and software, which makes a clear differentiation between hardware components and represented information nearly impossible. The design possibilities to support best the operation conditions range from highly abstract forms like simple service robots [12] to more realistic animalistic forms for example for entertainment and humanoid models like the ASIMO by HONDA.



Figure 11 (left): Service Robot [44]; Figure 12 (center): AIBO [10]; Figure 13 (right): ASIMO by Honda [45]

3. Design origins, concepts and problems

The presented UI models of intelligent assistance systems illustrates, a wide range of possible interaction types from simple GUIs to complex three-dimensional virtual or real artifacts. The commonalities of these models are their intelligent software systems and their intention to support humans in different processes of professional or private activities. The presented examples show the context between technological feasibilities and the development of UI representation forms over the last decades. According to the classification of GROH (2007) WIMP UIs represent types of indirect interfaces [13]. Those are characterized by a phase shift between the actions of the user and the reaction of the technical system. The interface in between is on a high level of abstraction and basically built up of icons and symbols. In contrast at present the technological development made possible, that the interaction between the user and the system takes place in real time. This leads to more naturalistic representation models like ECAs, VUIs and autonomous robots. These examples are types of direct interfaces, which are more iconic representations of reality. Beyond that UIs are always developed and related to specific scenarios. The shown examples may be used for e-learning language software, online customer support or navigation systems. Therefore, different core aspects are in the center of UI design and development. On the one hand the design concepts result from user-related aspects like user-specific functional and psychological properties (emotion and motivation) or the benefit of well-known UI models. On the other hand scenario related aspects like the influence of environmental, technical or economic conditions that might affect assistance functionalities have to be considered. Generally an unspecific but natural uncertainty exists in the human mind against autonomously working technical systems and especially artificial intelligence [9]. The work of a computer system is virtual, because information itself is not visible in a common sense. Because there are no other objects comparable to a computer, it is difficult to develop an adequate mental model of what a computer is and does and questions whether we trust the information the system provides. There are several advantages and disadvantages, which are related to the different UIs. In consequence of a strong orientation to existing technical conditions there may occur adverse interferences concerning the perception and cognition of information (for example problems with speech and auditory interfaces [35] in [35] p. 349). Besides the functional and reasonable constellation of the system emotional aspects have to be also considered. There are numerous psychological studies concerning human conversational behavior and emotional aspects. Nevertheless, only some of these aspects can be reproduced by technical systems [7, 11, 25]. Furthermore the research concerning the psychological and social impact of such intelligent artificial systems and anthropomorphic representations is only beginning and insufficient. [7, 19, 20]

4. Functionalities and design features concerning the UI of intelligent assistance systems

4.1 UI Design features of intelligent assistance systems

To date there are numerous interactive systems integrated in different parts of our environment. Their number will increase in the near future and they will become smaller, lighter, more powerful and more intelligent [24]. The increasing availability and higher interconnection between different systems will enable us to work with them more frequently and in nearly all fields of private and professional life. Therefore it is necessary to establish guidelines for their systematic and useful development. For UI Design as well as Interaction Design and Experience Design the development of more generalized design features and categories should be emphasized. The presented examples as well as future ones may be composed and judged on typical design aspects like size,

shape or color. In Addition the following aspects are proposed to aid particularly the development of intelligent Assistance Systems:

1. The degree of physicality of the UI is an important design consideration. As discussed above it may range from intangible forms like VUIs to physically touchable objects like autonomous robots.

2. The localization of the system in relation to the user needs to be considered. The UI of the system could be designed as object or environment oriented or as a completely independent system. We suppose that there is a strong connection between the degree of physicality, localization of the system relative to the user and integration of all the functions of the UI of agent-based systems named before.

3. The behavior of the system describes the modalities of the system that address the user perception. It influences the interaction between the system and the user. It is not obvious which coherency exists between types of interaction and the interpretation of the system by the user as intelligent or autonomous system.

4. The degree of abstraction of the represented information differs from precise text and spoken words, to abstract icons and to different types of gestures; there may also be a correlation between the degree of abstraction and the reliability of information or the intelligence of the system.

5. The degree of anthropomorphism is a design criterion, which has to be mentioned apart from the others. There are potential benefits and disadvantages in highly realistic humanlike representations. Concerning the function of representing emotional aspects strong connections were proven [19, 29]. The influence of human-like representations on other functions of the UI has to be analyzed.

4.2 UI functionalities of intelligent assistance systems

The literature review clarified that agent-based software differs from conventional software in regards to function, structure and behavior. The function of the UI is to represent the characteristics of the system to the user in order to allow him the successful handing and control of the technical system in his own interests. Based on these problems we propose a list of agent-specific functionalities addressing usability, acceptance and social impact, which should be considered within the design process of these systems:

1. The design of the UI has to represent the reliability of information, which is provided by the system.

2. The UI has to represent the fundamental characteristics of agent-based software systems – intelligence, autonomy and interactive behavior – in an adequate manner so that the user is able to distinguish between conventional and agent-based systems.

3. The UI has to be transparent concerning the required user data. In respect to ethic guidelines regarding the development and handling of technical systems, the UI has to clarify if, how, when and why the system measures and records user-related data.

4. The UI should assure the autonomy of the user over the intelligent system. This is particularly relevant concerning the required support and the influence on the handling of user data.

5. The representation of emotional aspects should be provided through different multimodal functions of the UI.

6. Because the social impact of these systems is unclear up to now, the UI has to assure that the user is able to perceive the status of the system as intelligent but technical and artificial.

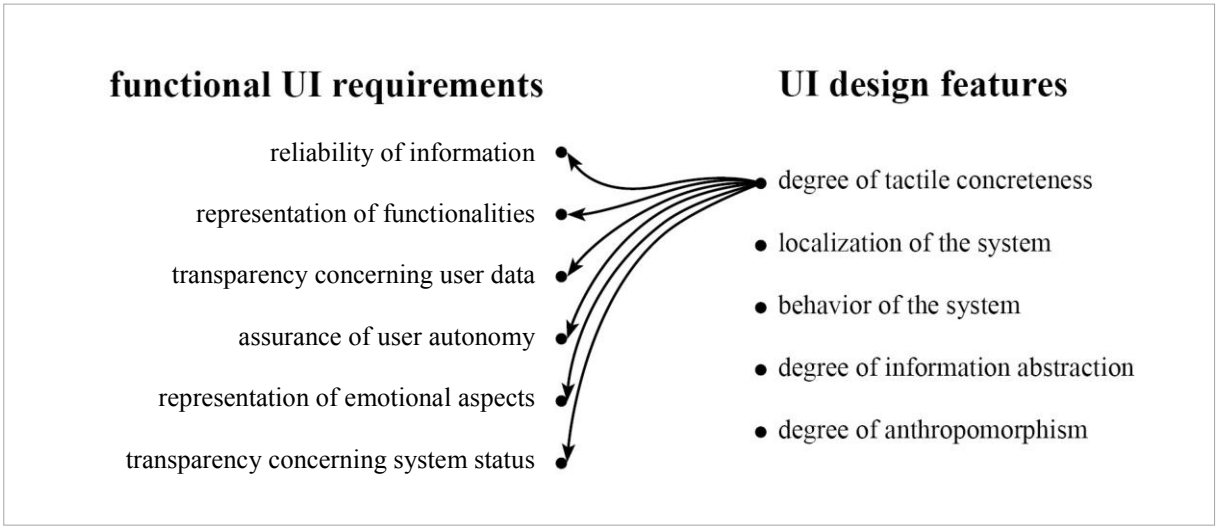


Figure 14: Influence of UI design features on functional UI requirements

5. Conclusions

Existing research data in the area of intelligent interactive systems usually focuses on specific UIs for concrete scenarios. Here we provide a general overview on the UI of intelligent assistance systems to identify similarities and distinctions between the UIs of these systems. The proposed UI functionalities and UI design features open a design space, which has to be analyzed over the next few years. As mentioned above, the virtuality of computer processes and information creates a substantial problem in intelligent computerized systems. Therefore we will consider in our future research the coherency between the degree of tactile perceptible concreteness and the main functions of the UI of those systems. A second milestone will be the development of more abstract solutions to transfer human shapes and human behaviors to the UI of intelligent assistance systems in a professional context. It should be analyzed which types of natural representation for direct interfaces are applicable in different contexts.

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